

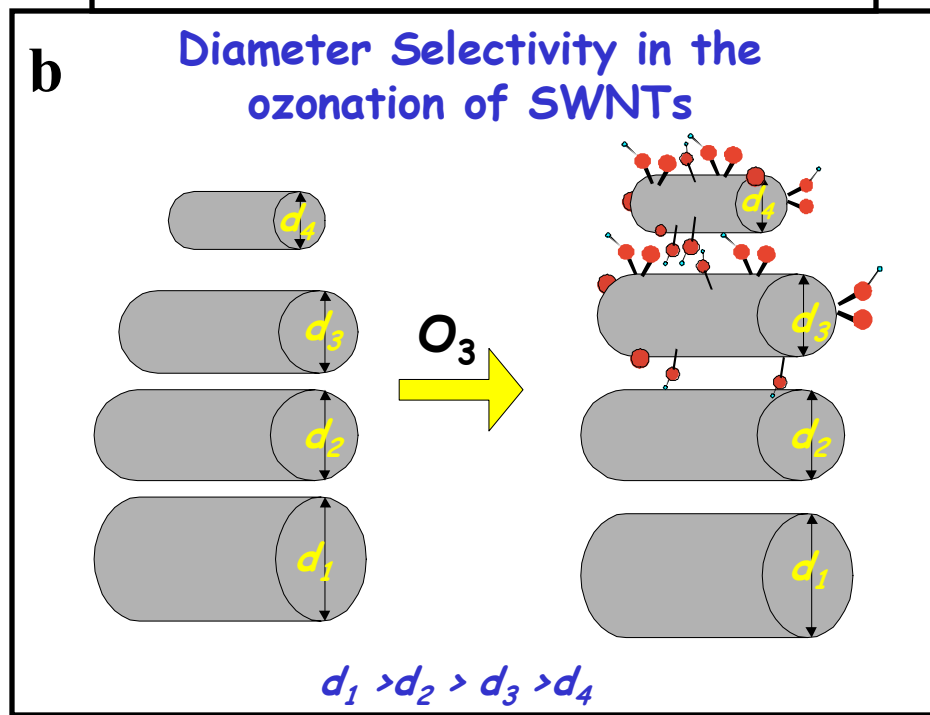
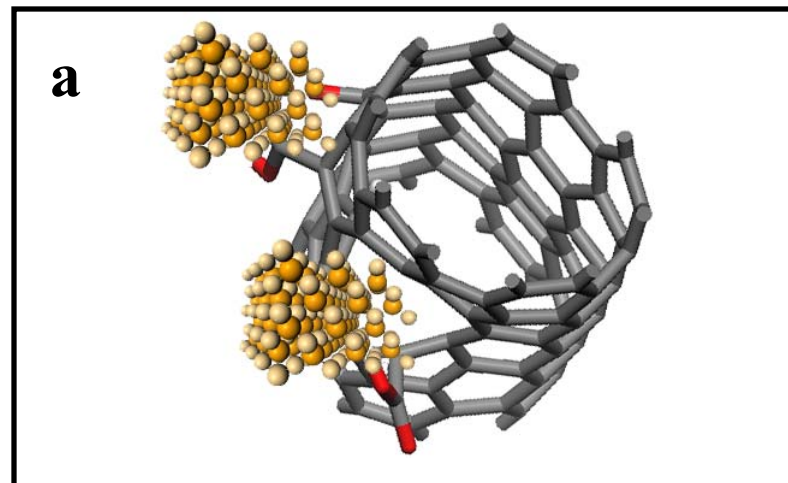
CAREER: Rational Synthesis and Studies of Functionalized Carbon Nanotubes

Stanislaus S. Wong, SUNY at Stony Brook, DMR-0348239

Understanding the **chemistry of carbon nanotubes** is critical to rational and favorable manipulation of their nanoscale properties.

(a). We have achieved the *in situ* formation of crystalline CdSe quantum dots on surfaces of oxidized, ozonized single-walled carbon nanotubes (SWNTs). This is a controlled synthetic route to the synthesis of complex hierarchical assemblies.

(b). We have demonstrated that in the solution-phase ozonolysis of SWNTs, **smaller diameter tubes react more extensively than larger diameter tubes**. This is a novel strategy of nanoscale separations on the basis of size.



- We have recently developed an ozonolysis protocol that purifies single-walled carbon nanotubes (SWNTs) by removing amorphous carbon and metal impurities. In addition, ozonolysis provides a new means for generalizing traditional chemistry to SWNT sidewalls and surfaces.
- (a). We have taken advantage of the presence of reactive oxygenated groups on the surfaces of ozonized SWNTs, which serve as templates for the guided chemical growth of CdSe quantum dots. In effect, functionalized, oxidized, ozonized SWNTs effectively nucleate coordinative formation of nanotube-nanocrystal heterostructures.
- Ref.: S. Banerjee and S.S. Wong, *Chem. Commun.*, (16), 1866-1867 (2004).
- (b). We have established that chemical reactivity of nanotubes in this sidewall addition reaction, i.e., solution-phase ozonolysis, is dependent on diameter. Smaller diameter nanotubes have greater strain energy per carbon atom due to increased curvature strain and greater rehybridization. The radial breathing modes in the low wavenumber region of nanotube Raman spectra indicate that, after functionalization, features corresponding to small diameter tubes are relatively diminished in intensity with a relatively minor alteration in the profile of larger diameter tubes.
- Ref.: S. Banerjee and S. S. Wong, *Nano Letters*, **4(8)**, 1445-1450 (2004).

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Education:

- **Two undergraduates** (Mark Cheng and Christina Arisio) and **four graduate** students (Sarbjit Banerjee, Tirandai Hemraj-Benny, Yuanbing Mao, and Tae Jin Park) contributed to this work.

- Cheng was a Summer 2003 REU fellow, supported by NSF. He continued with a senior's research internship during 2003-2004 and through Summer 2004.

- Arisio received a 2004 URECA summer fellowship from SUNY Stony Brook to pursue nanoscale research.

- Mao obtained a Sigma Xi Grant-in-Aid of Research in 2004.

- Banerjee received his Ph.D. in 2004 and is currently a postdoc at Columbia University.

Outreach:

- Maintained high school student, Daniel Nikbakht, in his lab since 2003.

- Hosted Gloria Lee on a Battelle-WISE scholarship and Vasiliki (Vicky) Zorbas on a Department of Homeland Security fellowship to learn about various instrumentation/facilities at BNL.

- Participated (see below) in the BNL and Columbia University REU Summer Symposium in 'Modern Materials and Materials Chemistry' - July 15, 2004.



Two undergraduates (Mark Cheng and Christina Arisio) and four graduate students (Sarbajit Banerjee, Tirandai Hemraj, Yuanbing Mao, and Tae Jin Park) contributed to the work presented. Banerjee was the key player in all of the experiments. Hemraj-Benny and Park participated in NEXAFS and NMR experiments, respectively. Cheng performed large scale chemical functionalization procedures, was associated with metal complexation work, and was involved in spectroscopic analyses of samples. Mao, Arisio, and Park also worked on an off-shoot of these efforts towards understanding the chemistry and physics of non-carbon nanomaterials.

One of the PI's outreach initiatives was to generate added intellectual exposure to BNL facilities for graduate and undergraduate students. The PI hosted Gloria Lee (undergraduate from SUNY Stony Brook) on a Battelle-WISE (Women in Science and Engineering) scholarship and Vicky Zorbas (graduate from UT Dallas) on a Department of Homeland Security fellowship to perform research using various instrumentation and facilities at Brookhaven National Laboratory. The students visited a range of facilities, including the NSLS beam lines, the Positron Emission Tomography Facility, a host of spectroscopy and magnetic resonance imaging labs in the Chemistry Department, and an AFM lab in the Materials Science Department, many of which they ended up utilizing during their summer stay.

As evidence of the PI's commitment to education at all levels, he has been mentoring a high school student, Daniel Nikbakht, in his lab since 2003. In addition, he participated, as an invited speaker, in the NSF-funded Brookhaven National Laboratory and Columbia University REU Summer Symposium in 'Modern Materials and Materials Chemistry' at Columbia University on July 15, 2004.